IMPACTS OF THE US HIGHWAY 53 EXPANSION PROJECT ON WOLVES IN NORTHWESTERN WISCONSIN

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IMPACTS OF THE US HIGHWAY 53 EXPANSION PROJECT ON WOLVES IN NORTHWESTERN WISCONSIN

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ADMINISTRATIVE SUMMARY

This report summarizes findings directly related to the impacts of upgrading the 44-mile (71 km) segment of US Highway 53 between Trego and Hawthorne from 2-lanes into 4-lanes on wolves (*Canis lupus*). The research was conducted from May, 1992 through June, 1999 and involved personnel from the Wisconsin DNR Bureau of Integrated Sciences Services and the University of Wisconsin-Stevens Point. Our main objectives were to assess the impacts of the highway project on resident and dispersing wolves, and to develop guidelines for minimizing any negative impacts of future highway projects on wolves.

Four UW-Stevens Point M.S. theses (Shelly and Anderson 1995, Gehring 1995, Unger 1999, and Frair 1999) were completed during the course of this investigation and are attached as Addenda 1-4. We incorporated their findings into this document without going into great detail on methodology or raw data analyses used in the theses. Please refer to the Addenda for specifics.

Fifty–nine wolves (33 males; 26 females) were captured, fitted with radio-collars, and monitored during 1992-99 to determine their numbers, movements, and mortality factors. Howling surveys were conducted during July-September to determine numbers of pups produced each year, and winter track searches were used to determine numbers of wolves in packs without radio-collared wolves and to detect the presence of newly-established packs. All known wolf mortalities were investigated and recorded.

We found no evidence that the highway project acted as a barrier to dispersing wolves. All but 1 of 13 radio-collared dispersers that encountered US 53 successfully crossed it, some of them multiple times. Those dispersers eventually established new territories and became dominant animals in those packs.

The US 53 project also did not appear to have a significant negative impact on resident wolf numbers or their distribution. The wolf population in the study area increased from 18 animals in 5 packs in March, 1994 to 61 animals in 16 packs in March, 1999. Wolf survival, reproduction, and immigration continued to be adequate to allow for this healthy population growth.

Wolves expanded their range within the study area as the population increased, and the highway did not appear to affect their distribution. Seven of the 11 new pack territories established during this study were located adjacent to US 53, and 2 of those included US 53 within their territory.

Although 10 wolves were killed by vehicles during this study, only 3 of those accidents occurred along US 53. It appeared that dispersing wolves were much more cautious about crossing highways than resident wolves.

We were not able to determine if the “ballooned sections” along US 53 actually facilitated wolf crossings of the highway. Wolves definitely used these areas to cross US 53, and they may have provided some protection because wolves encountered vehicles coming from only 1 direction at a time. Deer and coyotes were willing to go through the underpass created by the Totagatic River Bridge, but no wolf tracks were found there. Two wolves crossed US 53 within 0.1 mile (0.16 km) of the bridge but neither used the underpass.

Data collected during this study resulted in models that will allow managers to identify potential wolf den and rendezvous sites in future highway projects. Wolves preferred to establish den sites near the center of their territory. Within that inner core they selected for areas with lower road densities. Most dens were dug into steep banks with sandy soils.

Wolves appeared to be more tolerant of roads and human disturbance at rendezvous sites than at den sites. Most rendezvous sites were established in lowland habitats within 55 yards (50 m) of a water source.

Another model was developed that can be used to identify "high", "moderate", and "low potential wolf crossing sites" and delineate areas where special attention may be given to facilitate wolf crossings in future highway projects. Wolves preferred to cross highways where they bisected large, homogeneous landscapes, especially lowland complexes. Wolf crossings were more likely to occur in areas providing greater visibility and ease of travel.

The results of this study must be qualified because US 53 had relatively low traffic volume compared to most Federal highways, and the upgrade involved only adding 2 lanes to an existing highway corridor. Rerouting or creating new highways through wolf habitat could result in more significant problems. Future increases in traffic volume, speed limits, and/or human development and land use changes along the US 53 corridor could result in more serious impacts than found to date.

The authors suggest that the entire network of highways and railroads within the wolf range in Minnesota, Wisconsin, and Michigan be considered when planning future upgrades of existing highways or construction of new travel corridors. Wolves require large territories with low road densities, and need to disperse long distances to maintain genetic diversity throughout their range. Specific recommendations are provided which should be useful when designing highway projects through areas considered important wolf travel corridors or habitats.

We believe that this document satisfies the research requirements stated in the USFWS "Biological Opinion For Construction Of U.S. Highway 53 (Trego To Hawthorne), Washburn And Douglas Counties, Wisconsin". We would like to thank the Wisconsin Department of Transportation for their financial support and cooperation during this study. Their personnel were always very friendly and helpful whenever we encountered them in the field or asked for assistance. The Oversight Committee appointed to this project provided the support and guidance necessary for the successful completion of our work.

INTRODUCTION

Jackson (1961) and Wydeven (1993) estimated that 3,000 to 5,000 wolves lived in Wisconsin during pre-settlement times (<1832). The state legislature instituted a bounty on wolves in 1865 (Thiel 1993), and wolves were exterminated from southern Wisconsin during the 1880's (Schorger 1953). The last wolf in central Wisconsin was killed in 1914, and by 1930 only 150 wolves remained in the northern portion of the state. The last wolf pack in Wisconsin disappeared in 1956-57, and the last Wisconsin wolves were killed in 1958 and 1959 (Thiel 1993).

The gray wolf was considered extirpated from Wisconsin between 1960 and 1975 (Thiel 1978). A pack of wolves was discovered on the Wisconsin-Minnesota border just south of Duluth-Superior during the winter of 1974-75 (Thiel 1993), and the Wisconsin Department of Natural Resources (WDNR) listed wolves as endangered in 1975. The US Fish and Wildlife Service (USFWS) had previously listed wolves as a Federally Endangered Species in 1967.

Wisconsin's wolf population began to rebuild quite rapidly with the Federal and state protection plus increased human acceptance. When this study began (1992) there were a minimum of 45 wolves in 13 established packs in the state (Wydeven 1992). By March, 1999 there were a minimum of 197 wolves in 54 packs in northern and central Wisconsin (WDNR 1999). The WDNR initiated efforts to downlist wolves to state threatened status in the spring of 1999. This will require Federal downlisting or delisting which is currently in progress.

When the Wisconsin Department of Transportation (WDOT) proposed to convert a 44-mile (71 km) segment of US 53 in northwestern Wisconsin from 2 lanes into 4 lanes, there was concern that the highway project could have a negative impact on the recovery of Wisconsin's wolf population. The US 53 project passed through areas inhabited by wolves, and crossed the main dispersal route for wolves coming from Minnesota into Wisconsin (Fig. 1).

An “Eastern Timber Wolf Biological Assessment for U.S. Highway 53” was prepared by WDOT (1990). Wolf experts from Wisconsin, Minnesota, and Michigan were solicited to discuss the importance of maintaining the dispersal corridor for wolves coming from Minnesota into Wisconsin, and modifications to the proposed highway design that might mitigate any negative impacts on wolves.

WDOT incorporated many of the suggestions offered by the panel of wolf experts into the design of US 53. Fences were not placed along the highway right-of-way throughout the segment under construction, and private access was limited to the current level to minimize further development. The bridges over the Totogatic River were designed to allow easy under-highway crossings by wolves, and WDOT “ballooned” the median in sections of the highway known to be wolf crossing areas (Fig. 2). In these areas they kept at least 325 feet (99 m) between centerlines of the 2 lanes, maintained existing natural cover in the median strip, and allowed wooded cover to come as close to the highway as engineering standards allowed. The wolf experts felt that these “ballooned areas” would facilitate wolf crossings of US 53.

The USFWS prepared their “Biological Opinion For Construction Of U.S. Highway 53 (Trego To Hawthorne), Washburn and Douglas Counties, Wisconsin” (USFWS 1991; Appendix A) after reviewing the Biological Assessment prepared by WDOT. They concluded that the highway project proposed by WDOT “was not likely to jeopardize the continued existence of the eastern timber wolf or result in the adverse modification of critical habitat”. However, they felt that “some of the highway activities proposed may affect the species by limiting the frequency and number of animals which may cross the new highway and may result in an increase of animals killed by vehicles using the new highway.

The USFWS strongly recommended that the Federal Highway Administration and the WDOT fund a comprehensive study to determine how the addition of 2 highway lanes to an existing 2-lane highway may affect the dispersal of wolves from Minnesota through Wisconsin, and how it may affect the movement, mortality, and recovery of Wisconsin’s wolf population. They felt that such a study would provide valuable insight into best management practices that could be applied to other highway projects in Wisconsin and other states with suitable wolf range. The WDOT contracted with the WDNR to conduct the research.

This research began in May 1992. Our objectives were to: 1) determine the impacts of the US 53 expansion project on resident and dispersing wolves, 2) determine the effectiveness of wolf crossing sites incorporated into the highway design, and 3) develop criteria for identifying/mitigating any negative impacts of future highway projects on wolves.

REVIEW OF RELEVANT LITERATURE

Previous research in Wisconsin, Michigan, Minnesota, and Ontario has suggested that wolf populations fail to sustain themselves in areas where road densities exceed 1.0 mile of linear road per mile^2 of land (0.6 km per km^2) (Thiel 1985, Jensen et al. 1986, Mech et al. 1988). Wolf populations were generally restricted to large blocks of land with road densities below this threshold.

The "Recovery Plan For The Eastern Timber Wolf (USFWS 1992) stated, "The desired future state is to manage average public road densities so as not to exceed 1 mile per square mile (0.6km/km^2) in the designated recovery areas in Michigan and Wisconsin, and in parts of Minnesota where road density is limiting wolf recovery." That document also provided 2 principles for guiding road development: "(1) the more access provided to wolf range, the more detriment there will be to wolves, (2) the higher the grade (i.e. standard) the road is, the more access it will provide." It warned that significant improvements in road standards may have negative impacts on wolves similar to those of increased road densities.

More recent research efforts confirmed that areas with lower road densities provided the best wolf habitat in Wisconsin (Mladenoff et al. 1995, Mladenoff et al. 1997, Wydeven et al 1999). These authors found that landscapes with less than 0.7 mile of road per mile^2 (0.4 km/km^2) had a 50% or greater chance of being settled by wolf packs if adequate space and prey were available. Areas with more than 1.0 miles of road per mile^2 (0.6 km/km^2) of land had less than 10% chance of being settled. Based on these criteria, they estimated there were approximately 5,830 mile^2 (15,100 km^2) of land in Wisconsin with a 50% or greater chance of being settled by wolves in the future. Most of this area (71%) occurred on Federal, state, tribal, county, or industrial forest lands (Wydeven et al. 1999).

Ruediger (1996) felt that one of the most significant factors affecting rare carnivore populations was the impact of our highway system. He stated, "Unfortunately, one of the unforeseen costs of our transportation system is an almost unfathomable slaughter of wildlife on our roadways, serious fragmentation of terrestrial and aquatic ecosystems, and the near certain loss of important species – not the least being many of our mid-sized to large carnivores. The public shares a lack of understanding about how highways affect wildlife, fish and native plant communities – and what the future outcome will be for many species if we fail to address this issue."

Reudiger (1996) stated that large carnivores are vulnerable to the impacts of highways because they typically have low population densities and reproductive rates, and require large home ranges. He listed 5 ways highways negatively affect large carnivores including: 1) direct mortality, 2) displacement and avoidance, 3) habitat fragmentation, 4) direct habitat loss, and 5) associated human development. He provided several examples of significant highway-related wolf losses in northwestern Montana, Jasper National Park, Banff National Park, Deerlodge-Beaverhead National Forest, and Yellowstone National Park.

Paul Paquet (personal communication 2000) stated that the wolf population in Banff National Park, Alberta had declined to only 2 wolves during Summer, 1999 as a result of mortalities along the Trans-Canada Highway and Railroad system running through the Park. Pup mortality has been very high along the highway and adult mortality has been very high along the railroad. He felt that the wolf population in Banff National Park would now be "ephemeral".

A variety of highway crossing structures for wildlife have been tested during the last 2 decades. Among the first was an underpass constructed in 1970 to facilitate crossings of Interstate 70 in Colorado by a migratory herd of mule deer (*Odocoileus hemionus*) (Reed et al. 1975). Highway underpasses and extended bridges, accompanied by fencing to funnel animals through the structures, have resulted in some reduction of highway related impacts on Florida panther (*Felis concolor coryi*) (Foster and Humphrey 1995), black bear (*Ursus americanus*), grizzly bear (*Ursus arctos*), cougar (*Felis concolor*), and wolf populations (Clevenger 1998). Although location of the underpasses probably had the greatest impact on use of underpasses by large carnivores, the amount of human use (hiking, biking, horseback riding, etc.) around the underpass and the "openess" and length of the underpass were best predictors of underpass quality (Clevenger 1998, Clevenger and Waltho 2000).

More recently, wildlife overpasses or land bridges have been built over highways to facilitate highway crossings by wildlife in Europe (Simonyi 1999). Soil from the surrounding area is used to cover these overpasses to allow for the growth of native vegetation, and some contain small ponds. As with underpasses, fences are used to funnel the animals to the overpass.

It appears that wildlife overpasses may be effective for more species of wildlife than underpasses. They are quieter, less confining, maintain normal ambient conditions, and can serve as passageways for mammals, reptiles and amphibians (Jackson 1999).

We did not find any reference to the use of "ballooned strips" to facilitate highway crossings by large carnivores.

Costs involved in constructing wildlife underpasses, overpasses, and "ballooned strips" are an important consideration in highway design. Ruediger et al. (1999) felt that efforts to move wildlife safely across highways would result in improved human traffic safety. He stated, "much of the cost of providing safe wildlife crossings could be off-set by fewer vehicle collisions with wildlife, fewer human injuries, fewer human deaths, and lower vehicle repair and insurance costs."

STUDY AREAS

This study was conducted primarily in an area of approximately 2,700 mile^2 (7,000 km^2) in northwestern Wisconsin (Fig. 3). The study area (US53SA) included all lands west of the US 53 expansion project to the Minnesota border [approximately 25 miles (40 km)], and a strip of land approximately 12.5 miles (20 km) wide to the east of the highway project. The area is fairly undeveloped. Road densities within the study area range from 0.0-2.4 miles per mile^2 (0.0-1.5 km /km^2), and most of the land is in county, state, or industrial (paper company) ownership (Mladenoff et al. 1995).

The US53SA includes portions of Douglas, Burnett, Sawyer and Washburn Counties in Wisconsin. Although the city of Superior and 2 small towns (1,900-2,500 residents) exist on the highways surrounding the study area, Solon Springs and Minong (populations 500-600) are the only communities within the core of the study area. Logging, recreation, and some agriculture are the primary industries.

The topography in the study area is gentle to strongly rolling. The vegetation is predominantly an interspersion of upland and lowland mixed forests. The upland forest is composed primarily of sugar maple (*Acer saccharum*), basswood (*Tilia americana*), aspen (*Populus tremuloides*, *P. grandidentata*), paper birch (*Betula papyrifera*), northern red oak (*Quercus rubra*), jack pine (*Pinus Banksiana*), and red pine (*P. resinosa*). The lowland areas are primarily open bogs, sedge (*Carex spp*.) meadows, or marshes of black spruce (*Picea mariana*), white cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), black ash (*Fraxinus nigra*), and alder (*Alnus rugosa*).

US 53 runs north-south through the study area and is the primary arterial highway connecting Interstate 94 with the Superior/Duluth metropolitan areas. In 1996, the average daily traffic volume on US 53 in the study area was 4,700 vehicles per day (M. Hirshfield, WDOT, personal communication).

During 1992-96 we also radio-collared and monitored wolves in a peripheral study area of approximately 925 mile^2 (2,400 km^2) in east central Minnesota adjacent to the US53SA. The peripheral study area included portions of Pine and Carlton Counties, MN. Research was conducted in this area to help determine the amount of exchange of wolves between Minnesota and Wisconsin at that time. We terminated our research efforts in the peripheral study area in 1996 because the wolf population in the US53SA had reached adequate numbers for our research objectives by that time. Time and budget constraints had also reduced our ability to conduct further research in that area.

Data obtained from wolves living in the peripheral study area were included in the sections of this report dealing with dispersal and pack formation. They were not included in analyses or discussions regarding resident wolf numbers within the US53SA.

METHODS

Although all data were collected in metric units of measurement, approximate English equivalents are used in this document to simplify understanding. Actual metric units are shown in parentheses.

Wolves were captured during May-August in modified # 14 Newhouse traps. All traps were checked at least once daily. When ambient temperatures exceeded 80^{0}F (27^{0}C) we checked each trap in the morning and again in the evening. Animals were immobilized for handling with a mixture of ketamine hydrochloride (5mg/lb; 11mg/kg) and xylazine (0.9mg/lb; 2mg/kg). Once immobilized, wolves were fitted with radio-collars and marked with a numbered plastic ear tag. We attempted to have at least one radio-collared wolf in each pack at all times.

Blood samples were collected and analyzed for the presence of diseases and parasites. Body temperature, pulse rate, and respiration were monitored every 15 minutes while wolves were being handled. Wolves with body temperatures $\geq$103^{0}F (39^{0}C) were bathed in cool water or rubbed with methanol until their temperature started to fall. Those with body temperatures $\leq$100^{0}F (38^{0}C) were wrapped in a tarp or placed inside a warm vehicle until their temperature returned to normal. All trap related injuries were treated prior to release.

All collared wolves were located 1-2 times weekly from fixed-wing aircraft using procedures described by Mech (1974). Locations were plotted using GPS units. Wolves residing close to US 53, and dispersing wolves, were monitored more intensively from the ground. Ground locations were obtained by taking at least 3 bearings within a 20- minute period using a vehicle mounted, 5-element, Yagi directional antenna. Methods used to determine movements, activity patterns, and territory size/shape are described in detail in Shelley and Anderson (1995), Gehring (1995), Unger (1999), and Frair (1999).

Track searches were conducted during December-March to determine the distribution and numbers of wolves in the study area, the breeding status of each pack (Rothman and Mech 1979) and to locate highway crossings by wolves. Aerial counts were used whenever possible to estimate numbers of wolves in each pack.

Howling surveys during July-September were used to determine pup production/survival in each pack (Harrington and Mech 1982). These surveys were conducted shortly after sunset and were done by either howling in the vicinity of a radio collared wolf or by howling at 2-mile (3 km) intervals along roads within pack territories.

All wolf mortalities were investigated and necropsies were conducted at the USFWS National Health Laboratory in Madison. Methods and statistical tests used to measure/evaluate microhabitat and macrohabitat variables within wolf territories, along wolf trails, at den and rendezvous sites, and at wolf highway crossing sites are described in detail by Shelley and Anderson (1995), Gehring (1995), Unger (1999) and Frair (1999). Thorough discussions of the development of models for predicting wolf highway crossing sites and den and rendezvous sites are presented in Unger (1999) and Frair (1999).

RESULTS AND DISCUSSION

Trapping and Monitoring Success

Fifty-nine wolves were captured, fitted with radio collars, and monitored during this study (Fig. 4, Appendix B). These included 22 adult, 7 yearling, and 4 pup males and 11 adult, 13 yearling, and 2 pup females. The smaller numbers of pups and adult females captured was due to our reluctance to trap near known den and rendezvous sites during May-July to minimize chances of disturbing family groups.

Only 2 wolf mortalities resulted from our trapping and radio-collaring activities. One wolf apparently died from hyperthermia or capture myopathy shortly after it had been processed. The other mortality involved a male pup whose collar (fitted loosely to allow for growth) slipped up and over the lower jaw and lodged in the animal's mouth several weeks after being tagged. The pup subsequently died from malnutrition/dehydration.

None of the other wolves received serious injuries due to our trapping and handling. Most of them received only 2 or 3 small puncture wounds on the foot from the teeth on the trap jaws. The punctures were easily cleaned out and didn't require stitching. Antibiotics were administered to these animals to minimize chances of infection resulting from the wounds.

We prematurely lost contact with 20 of the 59 collared wolves. Seven wolves left the study area and monitoring was discontinued. It appeared that the collars malfunctioned on 6 wolves, and we suspect "foul play" resulted in the loss of 6 other wolves. Finally, the collar was chewed off 1 wolf by other wolves. Seventeen collared wolves were found dead (*see* "Wolf Populations in the US 53 Study Area"), and the collars expired when expected on 5 wolves.

Twenty-eight of the 49 wolves captured during 1992-98 provided information for $\geq$ 12 months. The 10 wolves captured in 1999 were not included in that tally at the time of this writing because 12 months had not elapsed since their capture. However, 1 of those 10 had been found dead and we had lost contact with another. Sixteen wolves in 15 packs were being monitored when data collections were completed for this study.

<u>Wolf Numbers</u>

Although this project began in May 1992, we weren't able to get our first reliable estimate of the numbers and distribution of wolves in the large US53SA until March 1994. That year pilot observations, telemetry data, and track searches produced an estimate of 18 wolves in 5 established packs (Fig. 5, Fig. 6, Table 1).

The estimated population increased to 30 wolves in 7 packs in 1995, 31 wolves in 8 packs in 1996, 46 wolves in 11 packs in 1997, and 53 wolves in 15 packs in 1998. The last surveys in this study (March 1999) produced an estimate of 61 wolves in 16 packs within the study area. The increases resulted in wolves expanding their range eastward in the study area.

Wolves expanded their range eastward in the US53SA as their population increased. Eleven new pack territories were established during this study. Seven of them were located immediately adjacent to US 53, and 2 of those included US

53 within their territory. It appeared that wolves often used the highway as a boundary between territories. US 53 formed the apparent physical boundary between 6 pack territories in 1999.

Our estimates must be considered conservative because they were based primarily on pilot observations of wolf numbers in known, established packs. It is quite likely that some packs were not discovered during the first winter they were established. And, lone, dispersing wolves were not included in our estimates because they were very difficult to census. Wydeven (personal communication 2000) found that 9% of 152 wolves radio-collared in Wisconsin during 1991-99 were loners. Fuller (1989) estimated that loners comprised 5-20% of total wolf populations in the Great Lakes Region.

Reproductive Success

Several howling surveys were conducted in most known packs within the US53SA each year (Table 2). Pup production was confirmed in 32 of the 56 (57%) packs surveyed and averaged 2.6 pups/pack. However, it was difficult to determine exact numbers of pups when $\geq$3 responded. We were unable to elicit responses from 13 of the packs surveyed, and only adults responded in 11 of the packs.

The howling surveys produced very conservative estimates of reproductive success. Follow-up observations by our pilots each winter suggested that 84% of the established packs produced pups each year during 1994-99.

Wolf Mortalities

Eighteen collared wolves were found dead during this study. Five were killed in collisions with vehicles, 4 were shot or snared, 3 died from mange-related complications, 2 were killed by other wolves, 2 died from capture related problems, and 1 died while giving birth. A necropsy has not yet been performed on the collared wolf found dead on August 19, 1999.

Other known wolf mortalities during this study included 5 uncollared wolves killed by vehicles, and 1 pup that was found dead at a den site. That pup was too decomposed to determine the cause of its death.

Wydeven et al. (1992) reported that 15 of the 29 (52%) radio-collared wolves found dead in Wisconsin during 1979-91 died from human caused mortality and that 12 (41%) of these had been shot. Excluding the 2 capture-related losses, 56% of the radio-collared wolf mortalities in this study died from human-related causes. But only 25% of the human-related mortalities were the result of shooting or snaring, and all but 1 of these occurred with wolves captured and killed in the peripheral (Minnesota) study area.

None of the 64 wolves radio-collared in Wisconsin during 1979-91 were killed by vehicles (Wydeven et al. 1992). However, collisions with vehicles accounted for 31% of the known radio-collared wolf mortalities in this study.

The mean annual survival rate for collared, adult (1+ years old) wolves in the US53SA was 81% (n=32). Wydeven et al. (1992) reported that annual survival rates for adult wolves in Wisconsin increased from 61% during 1979-85 to 82% during 1986-92. Apparently, survival rates for adult wolves in Wisconsin have remained near 80% for the past 15 years. Peterson et al. (1984) felt that annual survival rates exceeding 67% would allow continued population growth.

We collared only 6 pups during this study due to our reluctance to trap near known den sites, our fairly short trapping effort each year (May – August, 1992-96; May – June, 1997-99), and our unwillingness to collar animals weighing ≤ 25 pounds (11 kg). At least 4 of those (67%) survived at least 1 year after capture. We lost contact with 1 of the pups 8 months after its capture and were not able to determine if it had been killed and the collar was destroyed, or if the collar had failed. As discussed previously, the sixth pup died about 1 month after capture when the collar became lodged in its mouth (see "Trapping and Monitoring Success").

Population Growth

The average annual rate of growth (Caughley 1977) for the wolf population within the US53SA was 27% per year during 1994-99. Wisconsin's statewide wolf population increased on the average 29% per year during the same period (57 wolves in 1994 to 197 wolves in 1999) (WDNR 1999). Pup production and survival rates for both pups and adults were adequate to allow for this healthy population growth.

Wolf Dispersal

Data were collected from 20 dispersing radio-collared wolves during this study. Thirteen of the dispersers (12 females; 1 male) encountered US 53 in their travels. All but 1 of them crossed it; several of them numerous times (Fig. 7). Two of them, including the one that didn't cross US 53 while dispersing, established new territories adjacent to the highway and crossed US 53 occasionally after that. Nine of these wolves attained alpha status either by acceptance into an existing pack or through establishment of a new pack, 1 was killed while dispersing, and we lost contact with the other 3 before we could determine their fate.

Wolf Territory Sizes

Annual pack territory sizes within the US53SA during 1994-99 averaged 58 mile^2 (151 km^2) and ranged from 39-70 mile^2 (100-182 km^2) using the 95% Minimum Convex Polygon method (Mohr 1947). Annual territory sizes averaged 42 mile^2 (110 km^2) and ranged from 36-63 mile^2 (93-164 km^2) using the 95% Kernel method (Worton 1987, Seaman et al. 1999) (Table 3).

Shelley and Anderson (1995) calculated minimum convex polygon home ranges for wolves in the US53SA of 45 mile^2 (117 km^2) during the "denning and rendezvous" period (April - September), and 73 mile^2 (189 km^2) during the "nomadic" period (October - March). They also determined that mean home range sizes did not differ significantly between sexes, and that there were no distinct time periods during the day when wolves were most mobile during the “nomadic” period.

Territory Selection

Previous research in the Great Lakes Region has shown that areas with lower road densities provide the best wolf habitat, and that measurements of road densities provide the most widely accepted estimates of suitable wolf habitat (Thiel 1985, Jensen et al. 1986, Mech et al. 1988, Mladenoff et al. 1995, Mladenoff et al. 1997, Wydeven et al. 1999).

Frair (1999) compared the presence of roads within 494-acre (200-ha) plots centered around each of 3,448 independent radio locations of wolves (“used areas”) to the presence of roads within 3,535 randomly selected 494-acre (200-ha) plots outside of wolf territories (“unused areas”). Only 22% of the “used area” plots contained roads of any kind compared to 77% of the plots in “unused areas”.

She also found that total road densities were the best predictor of wolf habitat, and that the density of non-highway (township and unpaved forest roads) public roads better explained territory selection than either major or minor highway densities. Lands adjacent to non-highway public roads were used more often than those adjacent to highways for home and cabin sites, and for motorized and non-motorized recreation. People spent more of their time out of their vehicles along these roads than near highways.

Frair (1999) estimated potential within-territory tolerance limits of 0.14 miles per mile^2 (0.09 km/km^2) for major (state and federal) highways and 0.24 miles per mile^2 (0.15 km/km^2)for minor (county) highways. Only 1 pack studied occupied a territory that exceeded the major highway threshold, and individuals within that pack were not detected to cross the highway with any regularity. And, only 1 pack occupied a territory above the threshold for minor highways. No wolves occupied territories with non-highway public road densities greater than 0.5 miles per mile^2 (0.3 km/km^2). These data suggest the importance of considering not only road densities but also the types of roads when trying to determine suitable wolf habitat.

Wolves crossed non-highway public roads in proportion to their occurrence but avoided highways during their regular within-territory movements. Major and minor highways often defined the edges of pack territories. Wolf tolerance limits for highways may have partially affected the geographic positioning of pack territories in the landscape and the true carrying capacity.

Wolves were just starting to recolonize the study area during Frair's study (1992-96) and probably were able to select the most ideal areas to establish territories because of their low numbers (31 wolves; 8 packs). The wolf population within the US53SA increased up to 61 wolves in 16 packs by 1999, and preliminary analysis suggest that wolves now tolerate road densities higher than that found during Frair's study (Paul Keenlance; Michigan State University PhD candidate; personal communication).

Ruediger et al. (1999) stated that railroads constitute similar dangers to carnivores as highways and should be considered when evaluating the impacts of our transportation system on large carnivore populations. He cited works by Woods and Munro (1996), Paquet and Callaghan (1996), Gibeau and Heuer (1996), and Leeson (1996) showing that the Trans-Canada Highway and Railroad combination through Banff National Park, Alberta has resulted in significant wolf mortality and serious habitat fragmentation to wolves, grizzly bears, lynx, and wolverine. The whole transportation network should be considered when making decisions on future highway projects.

Selection for Den Sites

Unger (1999) found that location within the territory appeared to be the most crucial factor in the selection of den sites by wolves in the US53SA. Wolves selected for the inner 25% isopleth of their annual territory when establishing a den. Eight of the 9 den sites he examined were located within this inner core, and the other den site was located only 220 yards (200 m) from the border of this central area. He postulated that optimal foraging and avoidance of interpack strife were possible reasons for this pattern of selection. Landscape, forest type, and patch habitat variables were not significant predictors of den site location.

Within the inner core, wolves favored areas with lower road densities as den sites, and most were more than 0.6 miles (1km) from an improved road. This suggested that wolves preferred areas where human disturbance was minimal. Most of the dens were burrows dug into steep banks with sandy soils (Fig. 8). Only 2 of 13 dens were located under fallen trees.

These findings can be very useful when determining highway alignments in future projects bisecting known wolf habitat. The size and shape of individual wolf pack territories within the project area should be estimated via telemetry or track surveys to determine the inner 25% of those territories (Fig. 9). If the proposed highway alignment does not bisect the inner 25% of any territories, there will be little chance of them negatively impacting any potential denning sites. Further investigation should be done if the proposed alignment does bisect the inner 25% of a known pack territory. Alignments within this inner 25% should avoid areas with low road densities and with fairly steep, sandy slopes, especially those on islands within wetlands.

Rendezvous Site Selection

Ten rendezvous sites in 9 pack territories were located during this study (Fig.10). Of these, 4 were directly associated with streams, 2 occurred in shrub wetlands, 2 occurred in forested wetlands, and 2 occurred in upland forests.

Rendezvous site selection appeared to be controlled primarily by habitat factors rather than territory boundaries or roads. Wolves established rendezvous sites throughout their territory, not just the inner 25% isopleth as were den sites. Wolves appeared to be more tolerant of roads and human disturbance at rendezvous sites than they were at den sites. Several rendezvous sites were often in the immediate vicinity of a logging road or forest trail, and some were adjacent to heavily-traveled roads.

Wolves selected wetland habitats with close proximity to open water when establishing rendezvous sites. The availability of open water apparently played an important role in their site selection process. Pups are relatively sedentary at rendezvous sites and a permanent source of water at the site would be beneficial to pups for both digestion and hydration. Water may also play a role in temperature regulation during the hot summer months.

Within wetland habitats, wolves selected areas with dense ground vegetation and semi-open canopy. High dense grasses associated within the semi-open wetland habitats provided high visual obstruction at rendezvous sites. Areas with higher visual obstruction may have been selected to minimize possible conflicts between pups and intruders.

Unger (1999) developed a model from these data to aid in identification of potential wolf rendezvous sites. Backward stepwise logistic regression produced the following model: Z = 4.9902 - 2.5080*WETLAND MSI + 0.523*LSIM. MSI and LSIM are FRAGSTATS acronyms for Mean Shape Index and Landscape Similarity Index, respectively (McGarigal and Marks 1995). This model predicted 88% of the rendezvous sites correctly and 72% of the 78 associated random sites correctly for an overall classification rate of 73%.

Those findings suggested that the presence/absence of small, rare, isolated patches of wetland within a diverse landscape were the most important predictors of suitable rendezvous sites. Human disturbance near rendezvous sites was not found to be as significant of a problem as thought previously.

Wolf Crossings of US 53

Precise locations of 37 wolf crossings of US 53 were obtained during this study (Frair 1999) (Fig. 11). Twenty-five wolf crossings of other major highways in the US53SA (WI 27, WI 35) were also evaluated to determine habitats used by wolves for crossing highways.

The majority of crossings (76%) occurred along 3 stretches of the highway: 1) from 1.9 to 8.1 miles (3-13 km) south of Minong, 2) from the St. Croix River north approximately 3.7 miles (6 km), and 3) from 0.6 to 5.6 miles (1-9 km) north of Solon Springs. The remaining wolf crossings were more dispersed.

Most (81%) of the instrumented wolf crossings of US 53 during 1992-96 were made by dispersing animals. Wolf crossings of US 53 by dispersers peaked during late October through late December and from late April through early June. Crossings of US 53 by resident wolves were less time specific. Resident wolves appeared to be less particular about where they crossed highways.

Frair’s (1999) landscape analyses [composition within 494 acres (200 ha) of crossing site] of habitat variables at wolf crossing sites showed that "patch density", an index to human-induced fragmentation, was the most significant and consistent landscape indicator of favorable wolf crossing habitat. Wolves preferred to cross highways where they bisected large patches of unfragmented habitat. They avoided developed lands and did not cross highways in areas adjacent to homes, lakes, or large rivers.

Lowland complexes were the most preferred crossing habitats. Upland forests and shrub and grassland types were used in proportion to their availability. Large, unfragmented patches of the upland forest and shrub and grassland types were used because they provided the distance from human activity required by wolves when moving through the landscape.

Frair (1999) also measured biotic and abiotic variables (*in italics*) within the immediate vicinity of each crossing site and paired random sites. She found that wolves preferred areas with greater visibility and ease of travel for highway crossing sites. *Visual obscurity* at eye level was significantly lower at wolf crossing sites than at the random sites. *Visual obscurity* was highly correlated with *shrub density*, and both variables were correlated with *deciduous canopy cover*. All 3 of these undoubtedly related to ease of movement as well as visibility. *Snow compaction*, which also can be directly related to ease of movement, was greater at crossing sites than at the random sites.

Overall, other visibility related variables (*percent canopy cover*, *percent slope*, *maximum distance visible*, *relative* topography, *distance to opposite edge*, and *right-of-way width* were not significantly associated with crossing site selection or avoidance. But, wolves crossed WI 35 where the *distance to opposite edge* and *right-of-way width* were greater than found at random. Wolves did not show this selection when crossing US 53 where the right-of-way was wider than on WI 35. Distances crossed on US 53 were nearly twice those crossed on WI 35.

Gehring (1995) found that wolves also used man-made roads and trails extensively when traveling within their territories during winter. He concluded they selected travel routes with shallower snow depths, greater visibility, and lower vegetation stem densities. The man-made roads and trails provided these features.

And, Frair (1999) backtracked 9 trails made by wolves as they approached major highways. Twenty-three percent of the 12.4 miles (20 km) of wolf trails she followed coincided with groomed snowmobile trails, plowed roads, railroad tracks, deer trails or individual ski/snowmobile tracks.

Although these findings associated wolf movements with trails, there was not a significantly higher presence of *trails* at wolf crossing sites than at the random sites. Trails do provide wolves with the elements they preferred when crossing highways (less visual obscurity, more snow compaction, less deciduous overstory) and we expect that wolves opportunistically used trails which coincided with their intended direction of movement even if they led them across a highway.

<u>Highway Crossing Model</u>

Frair (1999) developed and tested several predictive models based on the analyses described above for identifying potential wolf crossing sites along major highways. These models were tested/validated by comparing their predictions of suitable crossing habitat to 15 actual wolf crossing sites of US 53 that were not included in the initial development of the models.

The model with the highest predictive value used raster-based FRAGSTATS to compute landscape composition and pattern metrics within 494 acre (200 ha) sampling areas systematically placed every 100 m along US 53. The model assigned Resource Selection Function (RSF) values for each sampling area using the following formula: RSF = exp (-1.0853*WATER - 0.4295*PD - 0.2215*URBAN + 0.0635*LOWLAND). In this formula WATER = % of sampling area in open water; PD = patch density; URBAN = % of sampling area in developed land; LOWLAND = % of sampling area in forested or non-forested wetland. Although this equation appears complicated, it is written in a standard format for GIS application.

Sampling areas with RSF values >3.000 (60% of the known crossings) were labeled as "high potential crossing sites", and those with RSF values between 0.111 and 3.000 (40% of the known crossings) were labeled "moderate potential crossing sites. Sampling areas with RSF values <0.111 (did not contain any of the known crossing sites) were considered to have low crossing potential. The model then plotted the areas with “moderate” and “high” probability wolf crossing sites (Fig. 12).

Frair's model worked well for identifying potential wolf crossing sites along US 53. Fifty-nine percent of the known wolf crossings of US 53 occurred in areas labeled as "high potential crossing sites" and 34% occurred in areas labeled as "moderate potential crossing sites”. Only 7% of the wolf crossings of US 53 occurred in areas labeled as "low potential crossing sites".

"High" and "moderate probability” crossing sites comprised 20% and 48% of the US 53 corridor being studied. This indicated high connectivity between habitats along and east and west of US 53. The model would have shown a lower proportion of “high” and “moderate probability” crossing sites if applied to highways running through less contiguous habitats.

Currently, only 9 miles (14.2 km) of the US 53 project falls into the “high probability” crossing site category. Expanding human populations and increasing recreational use of the landscape could narrow suitable crossing areas over time. Monitoring should be continued to document wolf crossings as human habitation and land use patterns change. Impacts of the highway on resident and dispersing wolves could become significant if suitable crossing areas narrow into discrete corridors while traffic volume increases.

Wolf Use of "Ballooned" Strips and Underpasses

The "ballooned" sections of the highway were located in appropriate spots. Eighteen of the 37 known wolf crossing sites along US 53 occurred in "ballooned" areas, and all 3 of the longer ballooned sections fell within or partially overlapped areas described as "high probability wolf crossing sites" earlier in this document. One dispersing wolf used "ballooned" sections to cross the highway at least 6 times. And, one pack established a territory immediately adjacent to one of the "ballooned" sections and occasionally used it to cross the highway.

In 3 cases radio-collared dispersing wolves were monitored continuously when approaching/crossing US 53 at one of the "ballooned" areas. The first wolf remained close to US 53 for 1-2 hours and then trotted across the "ballooned" section during daylight hours. The second wolf remained near the highway for several hours during the daylight and finally crossed after darkness and traffic was reduced. This wolf also crossed the "ballooned" section in a hurry. The third wolf crossed a "ballooned" area without hesitation during daylight hours.

In a few cases we were actually able to watch wolves as they crossed highways. They seemed to easily avoid vehicles coming from only 1 direction but appeared somewhat confused when vehicles were coming from both directions. The "ballooned" sections minimized this problem because wolves encountered only 1 direction of traffic at a time. More recent observations of resident wolves suggest that they have become more accustomed to vehicular traffic and much less wary than dispersers when crossing US 53.

Initially it was thought important to maintain cover as close to the road right-of-way as possible and to maintain/establish cover within the median strip in "ballooned" areas to make them more attractive to wolves. We now feel this is unnecessary because wolves have shown a preference for crossing sites which afford them greater visibility.

Regular checks under the Totagatic Bridge showed that deer and coyotes were willing to go under the bridge to cross US 53, but no wolf tracks have been found. No wolf activity was observed under the other bridges/overpasses along US 53 either. The observed use of the underpass by coyotes provided some evidence that the bridge design may provide safe crossing sites for wolves as well. However, we have found 2 wolf crossings of US 53 within 0.3 miles (0.4 km) of the underpass, 1 within 30 yards (30 m), and neither used the underpass to cross the highway.

Wolf Mortalities on US 53

Three wolves were killed by vehicles on US 53 during June-October 1998. These included a collared yearling female dispersing from the Frog Creek Pack, and a pup and a yearling male from the Stuntz Brook Pack whose territory included US 53. The dispersing female crossed US 53 at least 7 times during her travels.

All 3 vehicle/wolf collisions occurred in a 3-mile (4.8 km) segment of US 53 starting 2.5 miles (4 km) south of Minong (Fig. 13). US 53 runs through a large block of lowland habitats in this area and it was labeled a "high potential crossing area" by Frair's (1999) model. The highway is "ballooned" through much of this area and 2 of the mortalities occurred in the "ballooned" strip. Four lightly-used forest roads and trails crossed the highway in this segment, and all 3 mortalities occurred near the intersections of the forest roads/trails and US 53.

Innovative signing may reduce wolf mortalities in this area. The authors suggest placement of conspicuous “Caution!! EnteringWildlife Crossing Area” signs where motorists enter this area, and “reminder signs” stating “Wildlife Crossing” near the intersections with the forest roads and trails. This should also be done in the other “high probability crossing areas” discussed previously. And, it may help to quickly remove any deer killed by vehicles in these areas. Deer left along the highway could attract wolves for extended periods of time making them more vulnerable to being struck by vehicles.

Although we found 10 wolves killed by vehicles in the US53SA, these 3 were the only documented wolf mortalities on US 53. Continued monitoring of wolf mortalities on US 53 will be necessary to document any increases in wolf-vehicle collisions as posted speed limits and traffic volume increase.

CONCLUSIONS

Ideally we would have been able to collect data before, during, and after construction occurred along US 53 to determine the full impact of the highway project on wolves. But, construction began early in 1992 before we were able to collect baseline data, and weather and permitting problems seriously delayed construction progress. Thirty-seven miles (60 km) of the highway project had been completed at the end of this study (June 1999), and the remaining 7 miles (11 km) were scheduled for completion later that year after the study ended. (Appendix C).

We found no evidence that the US 53 expansion project had a serious, negative impact on numbers of resident wolves (members of established packs) or the quality of wolf habitat adjacent to the highway. The resident wolf population within the US53SA more than tripled while US 53 was undergoing construction.

Wolf reproductive and mortality rates remained similar to those elsewhere in Wisconsin and the Great Lakes Region.

Seven of the 11 new pack territories established during the study were located immediately adjacent to US 53, and 2 of those included US 53 within their territory. US 53 formed the apparent physical boundary between 6 pack territories in 1999.

The expansion of US 53 from 2 lanes to 4 lanes undoubtedly removed some suitable wolf habitat. But, that loss was minimal because the expansion basically followed the old highway alignment. Highway projects following new alignments through wolf habitat could have a much more significant impact unless considerations are given to existing road densities, wolf den and rendezvous sites and "high potential crossing sites". We found a potential tolerance limit of 0.14 miles per mile^2 (0.09 km/km^2) of major highways within wolf territories. Exceeding that level may result in making those areas unsuitable wolf habitat.

We found no evidence that the US 53 expansion project acted as a barrier to dispersing wolves. Thirteen dispersing radio-collared wolves encountered US 53 during this study and all but 1 crossed it. Three of them crossed US 53 multiple times in their travels. All of the dispersers we were able to follow for more than 1 year eventually established new territories and became the dominant animals in those new packs.

Mladenoff et al. (1995) felt that preserving the integrity of this travel corridor was a key factor for the successful maintenance of the wolf population in the Great Lakes Region. Population viability analyses by Rolley et al. (1999) suggested that continued immigration of wolves from Minnesota through the US 53 project area greatly enhanced the probabilities of maintaining a viable wolf population in Wisconsin.

However, the impact of the highway expansion project on the mortality to resident and dispersing wolves cannot be determined until it has been completed and in full use. Three wolves were killed by vehicles while crossing US 53, and it seems inevitable that more wolves will be killed by vehicles as their population increases, as more resident packs become established adjacent to the highway, and if/when traffic volume increases substantially on the highway.

Ruediger et al. (1999) stated that highways with traffic volumes exceeding 4,000 vehicles per day definitely increased habitat fragmentation and highway mortalities for large carnivores. Traffic volume on US 53 was 4,700 vehicles per day in 1996 and appears to be increasing. It will be very important to continue monitoring future wolf mortalities in the US 53 Project Area to determine if they represent greater proportions of the wolf population, or if they are reducing the influx of new wolves from Minnesota.

Results from this study regarding wolf den and rendezvous site selection and highway crossing sites should help managers identify potential sensitive areas in future highway projects going through similar topography. Applying these models will require GIS coverages of habitat types, streams, rivers, lakes, existing roads, and human developments. These coverages are now available for most areas. Identifying potential den sites will also require adequate knowledge of the distribution of wolves in the area of concern.

Avoiding potential den and rendezvous sites will normally require only a few, if any, minor changes in preferred highway alignment. Identification of potential highway crossing sites will delineate areas where features such as box culverts, underpasses, hydrological bridge extensions, and "ballooned" strips may be considered to facilitate wolf crossings of the highway.

We were not able to determine if the "ballooned" areas along US 53 actually facilitated wolf crossings of the highway. The small number of documented wolf crossings of US 53 obtained during this study prevented determination of any survival benefits from the "ballooned" areas. Wolves definitely used these areas to cross US 53, but this was expected because they were placed in areas thought to be wolf crossing sites. The "ballooned" areas may have provided some protection to the wolves because they encountered vehicles coming from only 1 direction at a time.

The timing of this study and the delays in highway construction reduced our ability to evaluate the full impacts of the highway project on wolf mortality due to increased traffic volume and highway speed. We were able to document the continued expansion and growth of the wolf population during the construction period of this highway project, which is a very significant finding. Individual highway expansion projects can be designed to minimize their impacts on dispersing and resident wolves based on the results of this study.

RECOMMENDATIONS

Geographic Planning

Impacts of individual highway projects can be very significant and quite easily documented for rare species with small home ranges and limited, fragmented habitats. But wolves and other large carnivores require large territories and the ability to disperse long distances to maintain genetic diversity throughout their range. The cumulative impacts of our transportation system on these species should be considered and addressed at the geographic scale rather than by individual highway segments.

The entire network of highways and railroads within the wolf range in Wisconsin, Minnesota, and Michigan should be examined when considering future development of existing highways or construction of new travel corridors in the Great Lakes Region. This would require a comprehensive planning process involving the USFWS, the Federal Highway Administration, the DOT and DNR agencies from each state, and the public.

The status and distribution of wolves, road densities, and habitat connectivity should all be considered early in the planning phases for new highway projects. Intensive wolf monitoring activities are ongoing throughout the Great Lakes Region and there is substantial information available on wolf numbers, distribution, movement patterns, and habitat requirements. And, State and Federal agencies now have GIS capabilities which allow them to quickly determine road densities, habitat compositions, and human development in any given area. These 2 large data bases can be used to quickly determine if any future highway proposal occurs within our wolf range and, if so, where potential problems may occur.

Highway Alignment

Generally, highway projects that closely follow existing transportation corridors are less likely to negatively impact resident and dispersing wolves. These projects do not significantly increase road densities in any given area nor are they likely to remove much suitable habitat or disturb existing/potential den sites. Future highway projects should, wherever possible, follow existing roads as closely as possible.

When it is necessary to create a completely new highway alignment, it will be beneficial to look at data regarding existing wolf pack territories in the immediate area before considering specific alignment alternatives. The DNR has this information for most areas. The size and shape of wolf pack territories without a backlog of movement data from collared wolves can be sufficiently approximated in one winter of intensive track searches.

Complete avoidance of existing wolf pack territories with new highway alignments would be the ideal. If this is not possible, special precautions should be taken to avoid placing new highway alignments through the inner 25% of any known pack territories to avoid removing suitable den site habitats (*see* “Selection for Den Sites”). If the new alignment must run through the inner 25% of a known pack territory, attempts should be made to avoid those areas with the lowest existing road density and islands within wetlands. New alignments should be placed at least 0.6 miles (1 km) from known den sites.

Although we did not find any significant, negative impacts of the US 53 expansion project on movements of dispersing and resident wolves, much research mentioned previously from other areas has shown significant highway related mortalities to wolves and other large carnivores. The identification of wolf crossing sites in future highway projects may be critical, especially where landscape composition and use patterns limit suitable crossing sites, and where traffic volumes are significantly higher than those currently on US 53.

The highway crossing model developed in this study can be used to identify “moderate” and “high probability” crossing sites along completely new alignments in addition to those following existing roads. Normally, these will be areas where highways bisect large, homogeneous landscapes, especially lowland complexes. Within these, wolf crossings are more likely to occur in areas providing greater visibility and ease of travel.

The WDNR maintains records of all reported wolf observations. These, along with results from previous track searches can be used to further define likely wolf crossing sites.

“Ballooning”

The USFWS Biological Opinion (USFWS 1991) prepared for the US 53 project required several modifications in the highway design to facilitate wolf crossings including: 1) construction of “ballooned areas” at locations determined to be wolf dispersal areas, and 2) maintenance and establishment of woody cover within the median of the “ballooned areas” as close to the pavement edge as safety and engineering standards allow. We were not able to document that the “ballooned strips” incorporated into this project significantly reduced mortalities of wolves crossing the highway.

Intuitively it seems “ballooned areas” should reduce mortalities. We observed that wolves appeared to be confused by vehicles coming from 2 directions. They had to deal with traffic coming from only one direction at a time in the “ballooned areas”. Highways are often “ballooned” to avoid important wetland areas and these are the areas most commonly used by wolves as highway crossing sites. The additional cost involved in “ballooning” a highway may be offset by the benefits to both. There is a definite need for further evaluation of the effectiveness of “ballooned areas” in reducing wildlife mortality.

Right-of-Way Width

Our data suggested that it is not necessary to make special efforts to maintain or establish woody cover as close to the pavement as safety and engineering standards allow. Wolves preferred to cross highways in areas with greater visibility than found at random sites. The right-of-way along WI 35 is more narrow than that along US 53. The data we gathered showed that wolves preferred to cross WI 35 in areas where the right-of-way was wider than normal whereas this was not evident for the wolf crossings of US 53.

Access Limitations

The USFWS Biological Opinion stated that no additional road access sites were permitted in the US 53 Project to discourage secondary human developments from becoming additional barriers to wolf movements. This was a very good decision that should be included wherever possible in future highway projects traversing wolf habitat. Our data clearly showed that wolves avoided fragmented habitats caused by human development when crossing roads. Large increases in human development along a highway could make it necessary to go to much more costly efforts at limited crossing sites.

Underpasses and Fences

No wolves used the underpass created by the extension of the bridge over the Totogatic River. Such efforts may not be necessary in areas having large blocks of contiguous habitat on both sides of the highway. Previous research has shown that wolves and large carnivores will use underpasses if “forced to” by fencing, but that land bridges (overpasses) are preferred.

No fences were erected along the right-of-way in the US 53 project to avoid impeding wolf movements. That concession probably aided movements of dispersing wolves and should be considered in future highway projects going through large blocks of undeveloped land where livestock grazing and the potential for snowmobile and ATV traffic on the right-of-way are minimal. Fences have proven to be effective in directing animals into specific crossing sites and structures in areas where it has been found necessary to go to special efforts to insure their safety at limited crossing areas.

Signage

The Biological Opinion for this highway expansion project required “Wildlife Crossing Area” signs placed at the “ballooned sites” to alert motorists of the potential of hitting wildlife in an attempt to minimize wolf losses. It stated that no direct reference to “wolf crossing” shall be made.

We feel that placing “Caution!! Entering Wildlife Crossing Area” signs where motorists enter “moderate/high probablility” crossing areas described in this document could help minimize wolf losses. The signs will have to be obvious and unique to catch and hold motorists’ attention. Erecting smaller, “reminder signs” at well-used crossing sites (eg. where logging roads and lightly used trails occur directly opposite of each other on opposite sides of the highway) within the crossing areas may further help to keep motorists alert. Planting of grasses less desirable to deer in the right-of-way and quick removal of any deer killed by vehicles in these crossing areas could also be beneficial.

Road densities, traffic volume, and land use patterns will all determine the extent of mitigation efforts we will have to take in the future to safeguard the status of our wolf population. It has been found necessary to go to rather extreme measures (underpasses, land bridges, trucks loaded on trains when traveling through very sensitive areas) to reduce highway-related mortalities on large carnivores in Banff National Park, Alberta due to high traffic volumes and very limited numbers of suitable highway crossing sites. Our data suggests we may not have to go to those extremes in the near future in the Great Lakes Region as long as wildlife needs continue to be considered in transportation system plans.

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Table 1. Established wolf packs in the US Hwy 53 Wolf Study Area, 1994-99.

	NUMBERS OF WOLVES IN EACH PACK					
PACK NAME	1994	1995	1996	1997	1998	1999
Crex Meadows	3	5	4	3	3	2
Crotte Creek	6	3	7	10	7	4
Empire North	3	6	5	6	5	6
Moose Lake	2	4	5	3	4	4
Truck Trail	4	8	3	7	3	3
Chases Brook		2	2	3	4	4
Stuntz Brook		2	2	5	5	5
Moose Road			3	3	5	3
Riverside				2	3	2
Shoberg Lake				2	4	7
Tranus Lake				2	0	2
Buckley Creek					2	3
Chain Lakes					2	3
Empire South					2	4
Frog Creek					2	5
Sanctuary					2	4
Total Wolves	18	30	31	46	53	61

Table 2. Wolf responses to howling surveys conducted within the US Hwy 53Wolf Study Area, 1994-99.

	Numbers and Ages of Wolves Responding*							
PACK NAME	1992	1993	1994	1995	1996	1997	1998	1999
Crotte Creek	3A,0P	2A,2P	1A,2P	1A,4P	1A,0P	3A,3P	4A,2P	NR
Empire North	1A,0P	2A,2P	2A,2P	3A,3P	1A,2P	4A,3P	4A,3P	NS
Truck Trail	1A,0P	1A,0P	2A,3P	1A,1P	NR	3A,2P	1A,0P	2A,3P
Moose Lake	----	----	NR	1A,2P	NR	1A,2P	3A,2P	NR
Crex Meadows	----	----	NS	3A,2P	NR	NS	NR	2A,0P
Stuntz Brook	----	----	----	1A,0P	2A,3P	3A,3P	3A,3P	NR
Chases Brook	----	----	----	NS	NR	1A,0P	2A,3P	NS
Moose Road	----	----	----	----	1A,2P	1A,0P	3A,4P	NS
Riverside	----	----	----	----	----	1A,2P	2A,0P	NS
Shoberg Lake	----	----	----	----	----	NS	3A,2P	0A,3P
Tranus Lake	----	----	----	----	----	NS	NS	3A,3P
Sanctuary	----	----	----	----	----	----	1A,4P	4A,4P
Frog Creek	----	----	----	----	----	----	NR	3A,2P
Buckley Creek	----	----	----	----	----	----	NS	NR
Chain Lakes	----	----	----	----	----	----	NS	NR
Empire South	----	----	----	----	----	----	NS	NR

* A = adult(s); P = pup(s); NR = no response; NS = not surveyed; ---- = pack not established yet.

Table 3. Mean pack territory sizes within the US 53 Wolf Study Area, 1994-99. Territory sizes were estimated using 95% minimum convex polygon (Mohr 1947) and 95% Kernel (Seaman et al. 1999) methods.

		Mean Area (km^2)	
Year	Number of Packs	95% Minimum Convex Polygon	95%Kernel
1994	5	146	93
1995	7	100	164
1996	8	132	99
1997	11	182	107
1988	15	178	115
1999	16	137	94
Means		151	110

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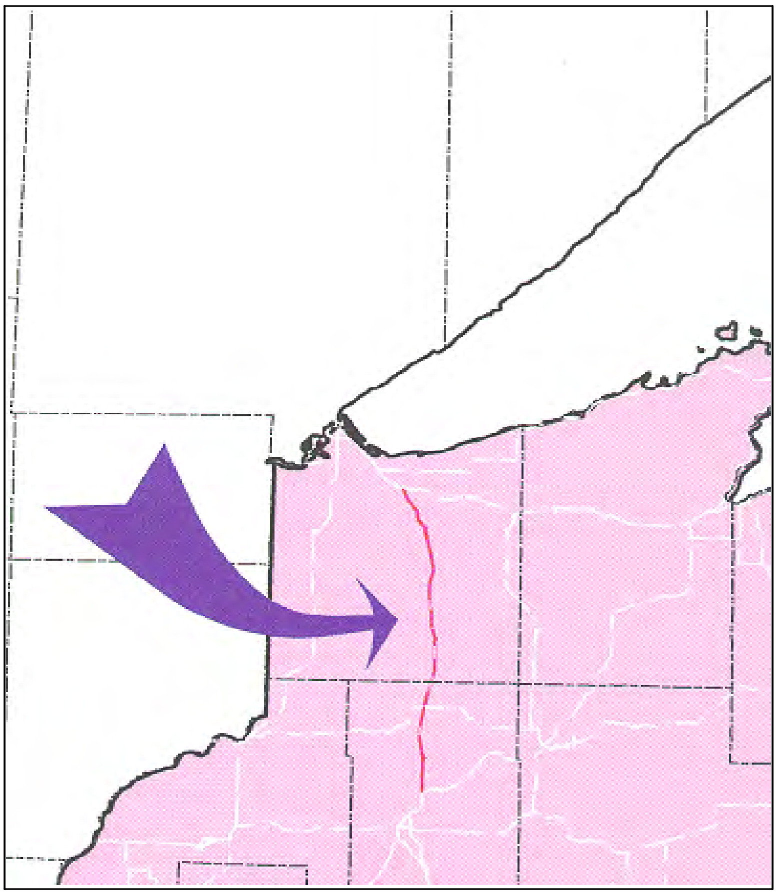


Figure 1. Main travel corridor for wolves coming from Minnesota into Wisconsin. Note that the U.S. Highway 53 Expansion Project bisected this main travel corridor.

FIGURE 2. "Ballooned strip" south of Minong under construction. The "ballooned strips" were constructed to facilitate wolf crossings of the upgraded highway. Natural vegetation was maintained in a median at least 100 m wide between the centerlines of the 2 lanes. Wolves crossing the highway in the "ballooned strips" would encounter traffic coming from only one direction at a time.

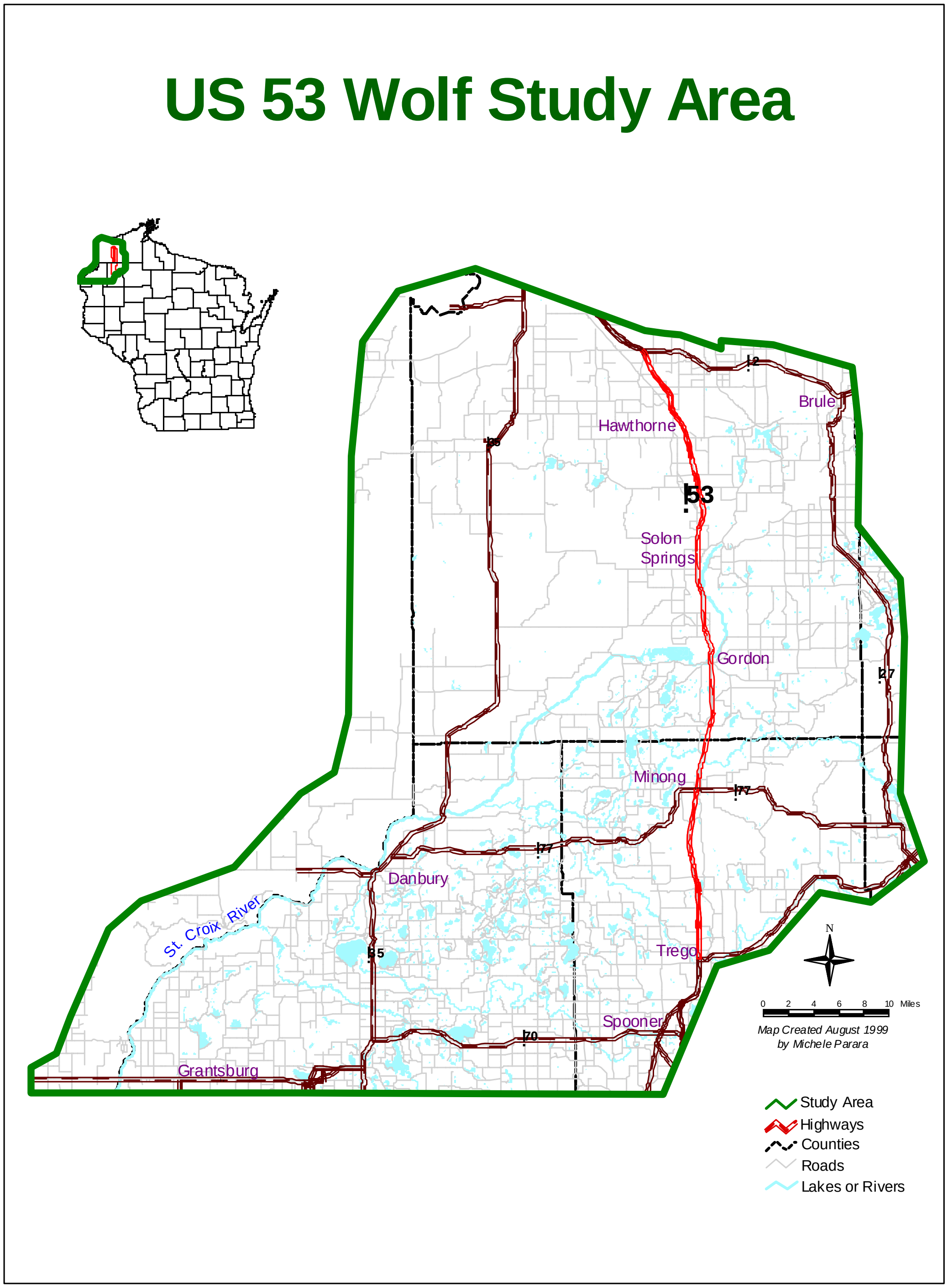


Figure 3. Location of the US 53 Wolf Study Area. This area included the main dispersal route for wolves coming from Minnesota into Wisconsin.

Photo by Woody Hagge

FIGURE 4. A total of 59 wolves were captured in modified leg-hold traps and fitted with radio collars to determine the impacts of the US Highway 53 Expansion Project on resident and dispersing wolves.

Photo by John Bronson

FIGURE 5. We tried to maintain at least one radio-collared wolf in each pack. This normally allowed the pilots to locate and count all of the wolves in the pack.

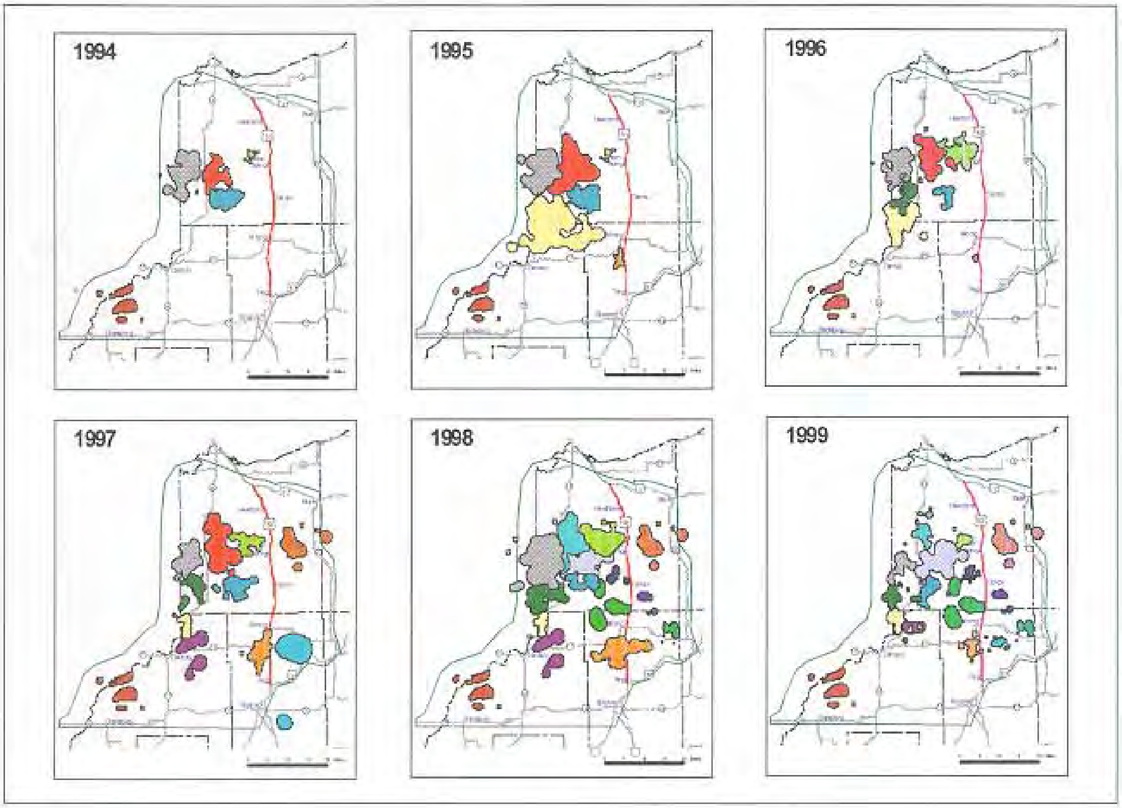


Figure 6. Established wolf pack territories in the US 53 Wolf Study Area, 1994-99. Areas with same colors represent different portions of the same pack territory. The population increased from 18 wolves in 5 packs in 1994 to 61 wolves in 16 packs in 1999. Note that 6 of the more recent packs were established adjacent to US 53.

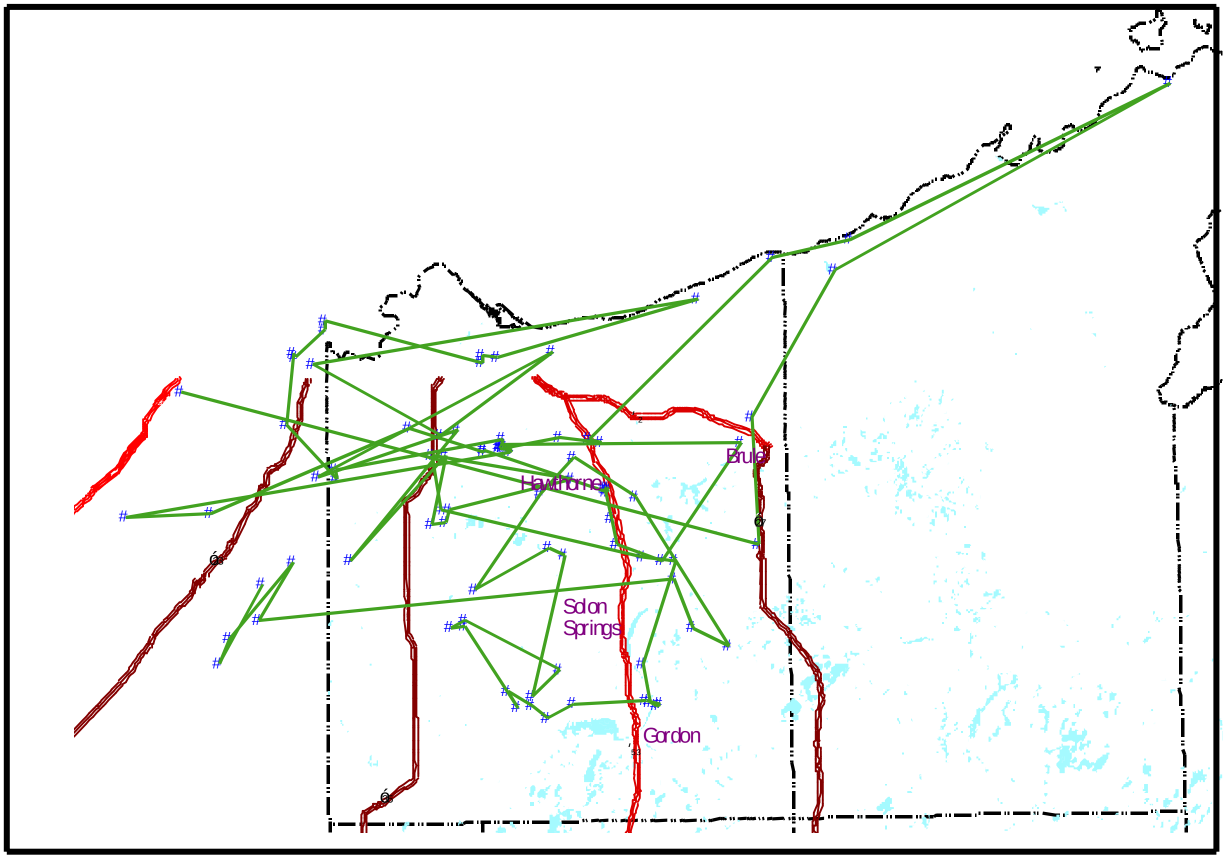


Figure 7. Movements of dispersing wolf #182. Note that she crossed US 53 at least 10 times during her travels. The US 53 upgrade did not appear to negatively impact the main travel corridor for wolves coming from Minnesota into Wisconsin or the movements of dispersing wolves within Wisconsin.

Photo by Alexa Spivy

FIGURE 8. Wolves located their dens in low road density areas within the inner 25% of their territory. Most dens were burrows dug into steep banks with sandy soils. This particular den went nearly 6 m into the bank.

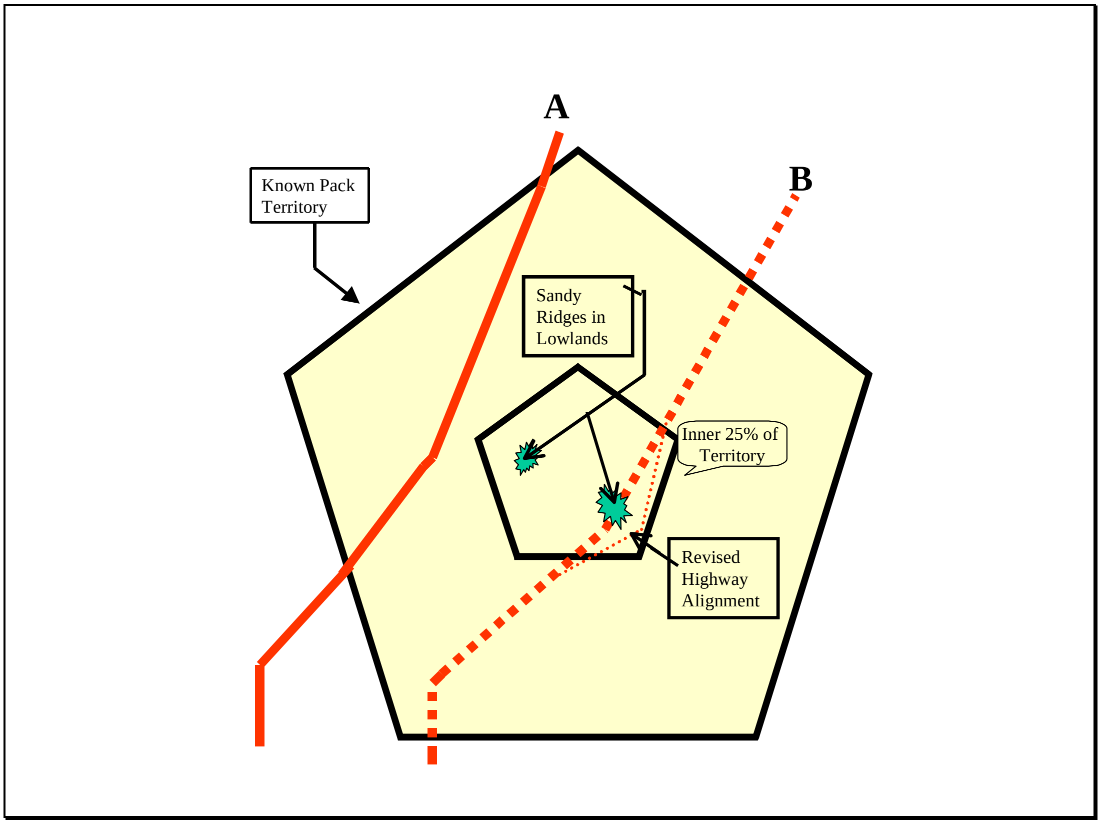


FIGURE 9. Example of the possible use of Unger's (1999) den site model when determining highway alignment through a known pack territory. In example "A", the proposed highway alignment does not bisect the inner 25% of the pack territory and, therefore, is not likely to impact any den sites. In example "B", the proposed highway alignment does bisect the inner core of the pack territory and further investigation is needed. If the proposed alignment runs through any sandy ridges within wetland areas in the inner core, it would be best to change the alignment somewhat to avoid that situation.

FIGURE 10. Wolf pups were kept at rendezvous sites while the rest of the pack was out hunting, patrolling the territory, etc. Most rendezvous sites were located in wetland habitats in close proximity to open water.

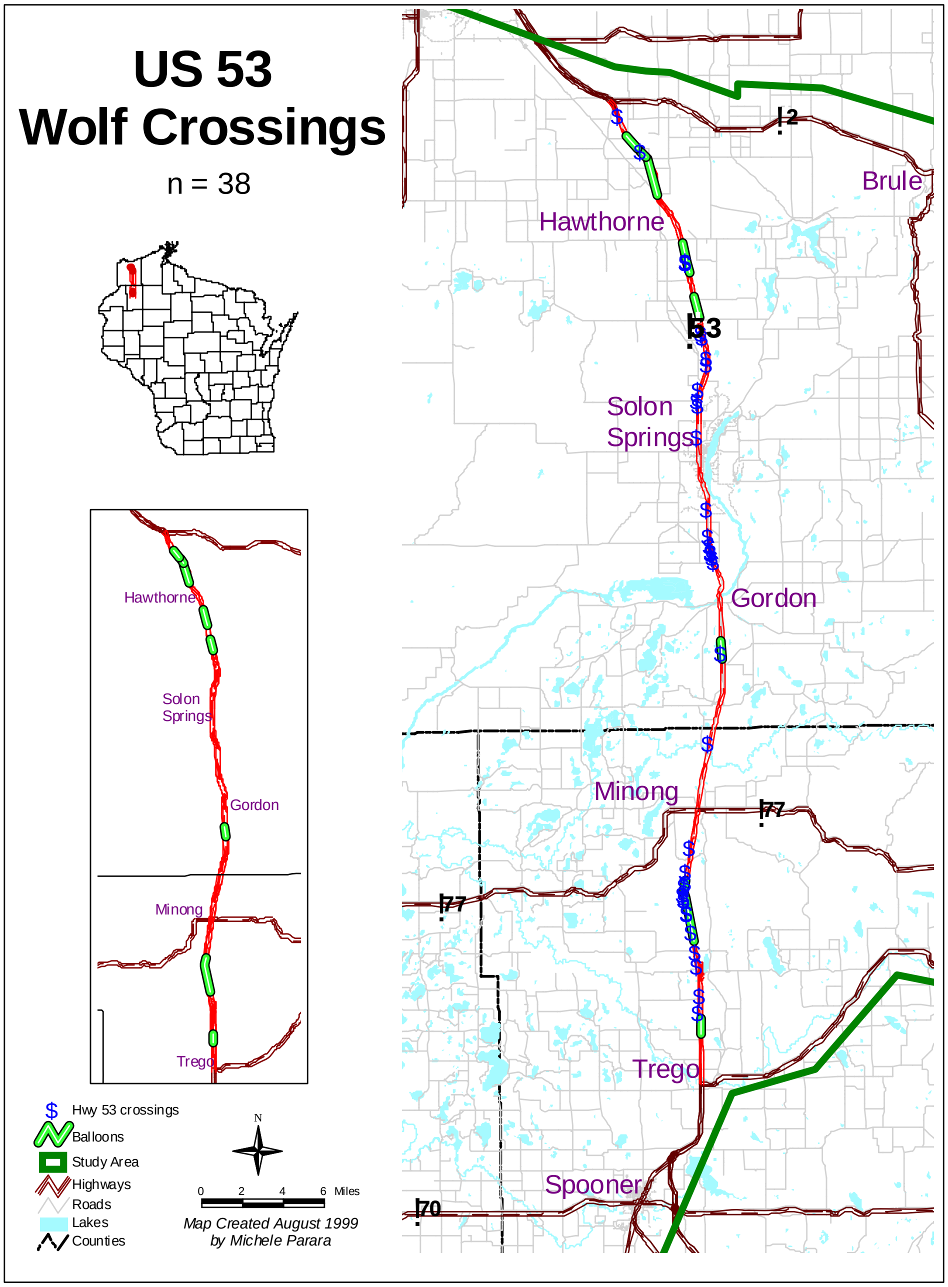


Figure 11. Locations of wolf crossings of US 53, 1992-99. Almost 50% of Crossings occurred in the "ballooned" strips.

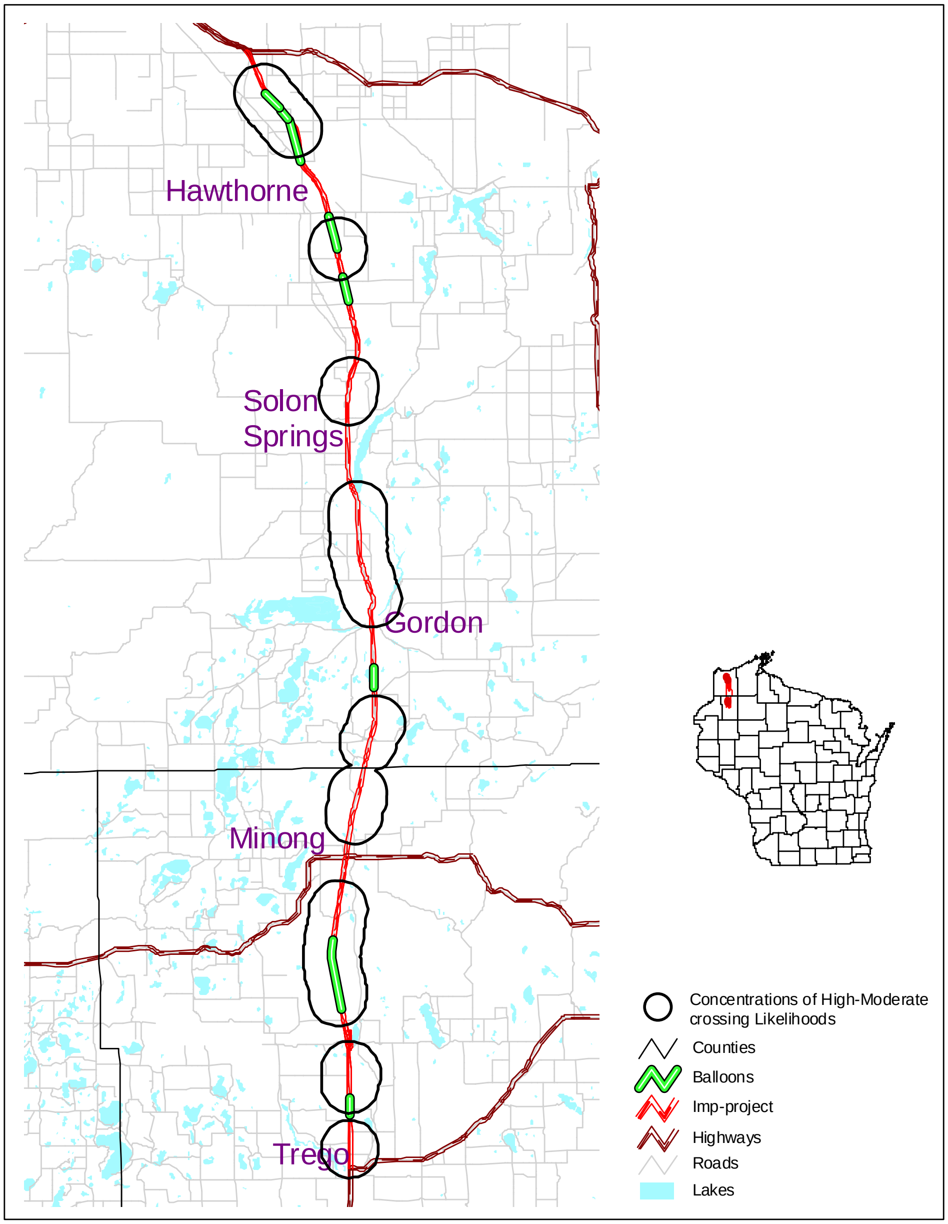


Figure 7. High probability wolf crossing sites of US 53 as determined by the predictive model.

Figure 12. Moderate-High probability wolf crossing sites on US 53 as determined by the population model. Note good agreement between placement of "ballooned strips" and the high probability crossing sites.

Photo by John Bronson

FIGURE 13. Segment of US Highway 53 where 3 wolves were killed by vehicles in 1998. The accidents occurred where forest roads and trails crossed the highway.

APPENDIX A. "Biological Opinion For Construction Of U.S. Highway 53 (Trego to Hawthorne), Washburn And Douglas Counties, Wisconsin" (USFWS 1991)

The following are excerpts from the USFWS "Biological Opinion For Construction Of U.S. Highway 53 (Trego to Hawthorne), Washburn And Douglas Counties, Wisconsin" that related directly to the necessity for and objectives of this study. Page numbers shown indicate where each excerpt can be found in that Biological Opinion.

Page 3: " The eastern timber wolf (subspecies of the gray wolf) is prevalent in the project area and may be affected by the proposed highway project. There is no critical habitat designated for this species in Wisconsin. An existing population of approximately 15 to 20 wolves in 4 or 5 packs currently lives in the project area in the forested sections of Douglas and Washburn Counties. These local wolves, along with wolves that disperse into northern Wisconsin and the Upper Peninsula of Michigan from the large wolf population (1550 to 1750) in Minnesota, primarily cross USH-53 in the project area. The wolves living in the project area constitute half of the present population of approximately 40 wolves in the State of Wisconsin. Further, the project route transects the only known dispersal route for wolves across the state. This dispersal route probably provided for the reestablishment of wolves in Wisconsin from Minnesota. It also provides for an influx of new wolves, thereby maintaining the genetic diversity in the state's wolf population."

Page 7: "Some of the highway activities proposed under the preferred alternative may affect the species by limiting the frequency and number of animals which may cross the new highway and may result in an increase of animals killed by vehicles using the new highway."

Appendix 1; page 1: "To monitor the incidental take of wolves in the project area along USH-53, wolf activities need to be surveyed prior to, during, and after highway construction of the selected alternative so that we can identify the existing take level and monitor future taking of wolves. Such a monitoring survey shall be designed by members of the wolf expert committee through coordination by the Service's Green Bay Field Office. This survey in the project area shall include a census of the wolf population through standard field techniques including radio telemetry to determine pack locations, numbers, composition, and local movement and long distance dispersal patterns."

Appendix 1; page 2: "A study shall be conducted to determine areas of wolf movement and crossing points along the 44-mile highway corridor, particularly from Solon Springs south, to identify appropriate "balloon" sites."

Appendix 2; page 1: "There is very little information available on the impact of highways on wolf dispersal and mortality. This highway project provides an opportunity to study how the addition of two highway lanes to an existing two-lane highway may affect the dispersal of wolves from Minnesota through Wisconsin and may affect the movement, mortality, and recovery of Wisconsin's wolf population. Such a study should be undertaken now so that more conclusive data will be available for use in assessing impacts of future highway upgrade projects in northern Wisconsin."

Appendix 2; page 2: "The proposed comprehensive study differs from the monitoring studies prescribed in the Terms and Conditions Section in that wolf management practices proposed for the USH-53 segment would be evaluated to determine their effects on the local population of wolves and on wolves dispersing from Minnesota through Wisconsin. Best management practices could then be applied to other proposed multi-lane highways in northern Wisconsin and elsewhere.

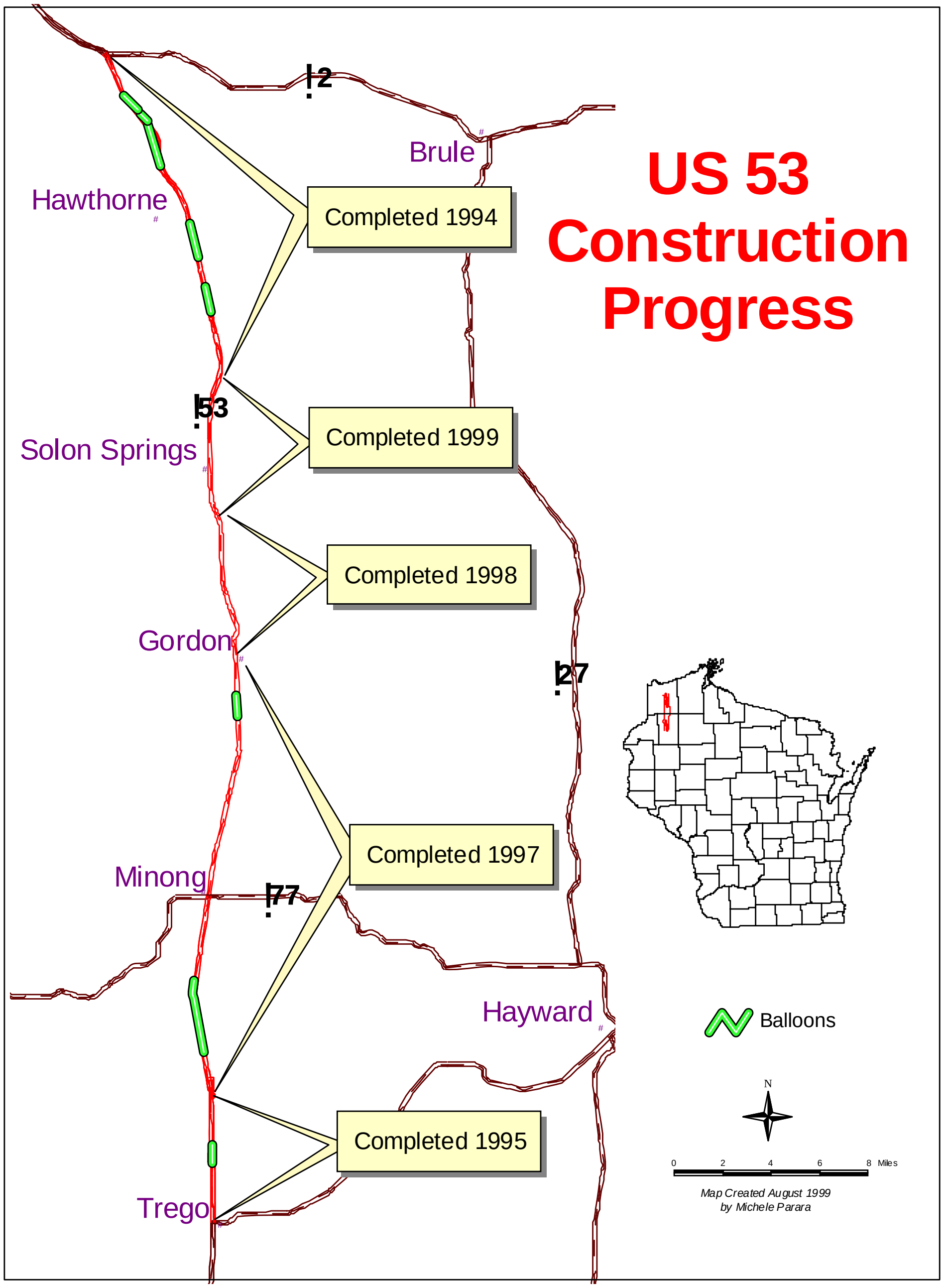
APPENDIX B. Radio-Collared Wolves Monitored In The US Highway 53 Study Area, 1992-99.

Wolf No.	Sex	Age*	Dates Monitored	Comments
149	F	A	1/92 - 7/92	died; snared in MN
133	F	Y	1/92 - 12/92	dispersed; lost contact
131	M	A	1/92 - 1/93	died; mange related
145	F	A	1/92 - 7/93	died; shot/snared in MN
183	M	A	5/92 - 9/92	died; vehicle collision
177	F	Y	5/92 - 12/92	dispersed off study area
203	F	A	7/92 - 1/93	died; mange related
205	M	A	8/92 - 12/94	died; shot in MN
207	F	Y	8/92 - 4/95	collar expired
189	M	A	5/93 - 7/94	died; vehicle collision
188	M	Y	5/93 - 1/96	died; mange related
500	M	A	5/93 - 8/96	collar chewed off
191	M	A	7/93 - 2/97	collar expired
192	M	A	8/93 -8/93	died; capture related
230	M	P	9/93 - 8/97	collar expired
221	F	A	5/94 - 5/96	died; intraspecific strife
185	F	Y	6/94 - 3/97	collar expired?
194	M	A	6/94 - 8/97	died; vehicle collision
187	F	Y	7/94 - 7/97	collar expired
182	F	A	8/94 - 3/95	dispersed; lost contact
184	M	A	5/95 - 11/95	lost contact; shot in MN?
196	M	Y	5/95 - 11/95	lost contact; shot in MN?
195	F	A	5/95 - 8/97	died; vehicle collision
186	M	A	6/95 - 11/95	lost contact
199	M	A	6/95 - 9/96	lost contact
197	M	A	7/95 - 8/96	lost contact
200	M	P	8/95 - 9/96	died; capture related
209	F	P	8/95 - 12/96	died; intraspecific strife?
255	F	P	10/95 - 4/97	died; while giving birth
198	F	Y	5/96 - 6/96	dispersed; lost contact
210	F	A	5/96 - present	still monitoring
263	F	Y	7/96 - 4/98	lost contact; suspicious
264	F	A	7/96 - 1/97	lost contact
266	F	Y	8/96 - present	still monitoring
260	F	Y	8/96 - 11/96	died; shot in WI
267	M	A	8/96 - present	still monitoring
268	M	P	8/96 - present	still monitoring

174	F	Y	5/97 - 10/97	lost contact; suspicious
265	M	A	5/97 - 11/97	lost contact; suspicious
155	M	A	5/97 - present	still monitoring
724	F	A	5/97 - present	still monitoring
277	M	A	6/97 - 3/98	lost contact; collar failed?
278	M	P	9/97 - 5/98	lost contact; suspicious
246	M	A	4/98 - 6/98	translocated off area
281	M	Y	4/98 - 6/98	translocated off area
279	F	Y	5/98 - 5/99	dispersed off area
280	M	Y	5/98 - present	still monitoring
288	F	Y	5/98-10/98	died; vehicle collision
289	F	A	6/98 - 6/98	lost contact; collar failed?
290	M	A	5/99 - present	still monitoring
291	M	A	6/99 - present	still monitoring
292	M	Y	5/99 - present	still monitoring
293	F	A	5/99 - present	still monitoring
294	M	A	5/99 - present	still monitoring
295	F	Y	5/99 - present	still monitoring
296	M	Y	5/99 - present	still monitoring
297	M	A	6/99 - present	still monitoring
298	M	Y	6/99 - present	still monitoring
299	M	A	6/99 - 8/99	died; cause unknown

* Age at time of capture (A = adult; Y = yearling; P = pup)

APPENDIX C. Design and Schedule For US Highway 53 Improvement Project



ADDENDUMS

ADDENDUM 1: Douglas P. Shelley and Eric M. Anderson. 1995. Final Report: Impacts Of US Highway 53 Expansion On Timber Wolves – *Baseline Data*. University of Wisconsin – Stevens Point MS thesis. 32pp.

ADDENDUM 2: Thomas M. Gehring. 1995. Winter Wolf Movements In Northwestern Wisconsin And East-Central Minnesota: A Quantitative Approach. University of Wisconsin – Stevens Point MS thesis. 132pp.

ADDENDUM 3: David E. Unger. 1999. Timber Wolf Den And Rendezvous Site Selection In Northwestern Wisconsin And East-Central Minnesota. University of Wisconsin – Stevens Point MS thesis. 76pp.

ADDENDUM 4: Jacqueline L. Frair. 1999. Crossing Paths: Gray Wolves And Highways In The Minnesota-Wisconsin Border Region. University of Wisconsin – Stevens Point MS thesis. 57pp.